THE AËRONAUTICAL JOURNAL.

OCTOBER, 1908.

The Aëronautical Journal.

(PUBLISHED QUARTERLY.)

SUBSCRIPTION PER ANNUM (post free), 4s.

Communications respecting Advertisements to be addressed to the Publishers, "Aëronautical Journal,"

Messrs. KING, SELL & OLDING, Ltd.,
27, Chancery Lane, W.C.

Editorial communications should be addressed to the Editor,

53, Victoria Street,
Westminster, London, S.W.

NOTICES OF The Aëronautical Society of Great Britain.

At a Council Meeting of the Aëronautical Society of Great Britain, held at 53, Victoria Street, Westminster, on July 15th, 1908.

1. The following gentleman was elected a Vice-President of the Society:

MAJOR B. BADEN-POWELL (late) Scots Guards.

To date July 15th, 1908.

2. The following gentlemen were elected members of the Society:

DR. ROBERT LAURIE, M.D., B.Sc.

MR. ALBERT C. NESFIELD.

To date July 15th, 1908.

3. A Committee was appointed to report upon the feasibility of obtaining an experimental ground for the Society.

President.

MAJOR B. BADEN-POWELL,

Vice-President.

Members:

R. K. BALSTON, Esq.

THE VISCOUNT HILL.

4. The undermentioned lady has been elected an Hon. Member of the Society, in recognition of the distinguished services to aëronautical science of her late husband, F. H. Wenham, Esq., Hon. Member of the Aëronautical Society of Great Britain:

MRS. F. H. WENHAM.

MISCELLANEOUS NOTICES.

1. The following books and publications have been presented to the Library:

By COLONEL TROLLOPE (late Grenadier Guards).

"La Conquête de l'Air" (current numbers).

By MM. W. DE FONVILLE AND G. BESANCON.

"Notre Flotte Aerienne."

By MONS. VICTOR TATIN.

"Eléments d'Aviation."

By the "Smithsonian Institution."

"Researches and Experiments in Aërial Navigation," by S. P. Langley.

By V. S. FRANK, Esq.

Photographs of various Flying Machines.

2. The Press cuttings supplied to the Society during September quarter will be available for issue on November 1st, 1908. Any member who wishes to have them should apply to the Hon. Secretary on October 19th, 1908. They will be given to the first applicant.

3. Members and others contributing to the Journal are requested to kindly observe the following rules when drawing up their MSS.:

(*a*) Write on one side of the paper only.

(*b*) Leave a margin one inch wide on the left-hand side.

(*c*) Draw diagrams, etc., on very white paper with very black ink, as this greatly simplifies reproduction.

(*d*) Forward their communications to the Hon. Secretary at least 14 days previous to the date of the meeting at which the paper is to be read. Papers containing diagrams, sketches, etc., which it is required to show on lantern slides should be sent in as early as possible.

4. The following extract from the "Bollettino Socièta-Aeronautica Italiana" is published for general information:

"The diagrams of Dirigible Balloons, appearing on page 122 of No. 5 of the 'Bollettino,' and reproduced on page 93 of the 'AËRONAUTICAL JOURNAL OF GREAT BRITAIN,' were taken from an article by Mr. J. H. Ledeboer appearing in 'AERONAUTICS' (London, March, 1908). By an unfortunate oversight we omitted to acknowledge the source of these diagrams in either case."

Helicoptere v. Aeroplane.

By H. CHATLEY, Esq., B.Sc.

1.—CONTROVERSIES.

Ever and again in the history of aëronautical development during the last century there occurred a movement in favour of the hélicoptère or vertical screw machine, and now when flying machines have advanced to a practical stage the question again appears. Many will have doubtless followed with interest the series of letters which has been appearing in "Engineering" since early in the year, in the course of which several engineers of repute have advocated the hélicoptère in no uncertain manner.

The author has, therefore, ventured to think that a short paper comparing, as far as is possible, the hélicoptère and the at present favoured gliding machines, would interest the members of the Aëronautical Society. He would, in the first place, wish to say that his own opinion as to relative superiority of the two types is perfectly neutral.

2.—COMPARISON OF THE TWO TYPES.

It is argued by those in favour of the hélicoptère that the type is superior to others in the following respects:

(1) It takes full advantage of the propeller thrust without the mediation of an aëroplane or second supporting surface.

(2) It is independent of the speed of translation, and can hover over one spot.

(3) It is more stable, having no large surfaces of high resistance exposed to the air currents.

Against these the aëroplane advocates set the following:

(1) A hélicoptère is supported by the direct thrust of a propeller, while an aëroplane, by utilising a wedging surface, multiplies that thrust as far as lifting is concerned, from 3 to 20 times. Therefore, by reason of this multiplication, it is possible to lift a certain weight with an aëroplane with a less powerful and weighty motor than is required for a hélicoptère. (See Appendix A.)

(2) While the hélicoptère is undoubtedly superior in its capacity to hover, it would be at a most serious disadvantage in gaining speed, seeing that the helices themselves would have a very considerable lateral resistance and additional motors would be required.

(3) Apart from the small gyrostatic effect of the helices, a hélicoptère is in a state of neutral equilibrium, whereas an aëroplane of the right form, weight, and speed, may be automatically stable, or, with a little manipulation of mechanism, be made so.

There are other points, but none so serious as these, and the author proposes to devote his attention to them.

3.—PROPELLER THRUST.

Undoubtedly the question of the propeller should be placed foremost, and here at once we have a difficulty which seriously affects both sides of the question, viz., it is not possible to say what effect a propeller of given dimensions, driven at a given speed and a given slip by a motor of known efficiency, will produce, unless the propeller has already been tried under almost identical conditions. With marine propellers the difficulty is great, but in air it is even worse. Mathematical study of the subject is only a very poor crutch to lean on when designing a propeller, and yet when a new form is being thought out, calculation on

possibly false assumptions is unavoidable. It is a comparatively easy matter to get a rough value for the thrust from a propeller when the axis of the latter is not advancing, *i.e.*, when there is 100 per cent. slip, but when the slip decreases, the values given by calculation may vary 50 per cent. from the truth, and this is the very case which bears most on the subject and, at the same time, is most difficult to try by experiment. Certainly we can say that the thrust decreases with the slip, but the efficiency apparently increases up to a certain point. Applying this idea to the hélicoptère and accepting the claim of 40 lbs. thrust per H.P. made by several experimenters for their propellers, we may say that such a machine, with thrust blocks having little friction, might hover with a horse-power $= \frac{\text{Total Weight}}{30}$.

The aëroplaner would claim to lift, say, 5 × 40 lbs. per H.P., but, as a matter of fact, he does not do so, for the reason that, although he may have a lift to drift ratio of 5 to 1, yet when the required speed has been reached the thrust is no longer 40 lbs., but possibly only 6 lbs. per H.P., so that the actual lift is no better than that of the hélicoptère.

Nevertheless, this same fact will prevent the hélicoptère from attaining great heights, seeing that great vertical velocities (and consequent decrease of slip) would cause decrease of thrust.

It has been suggested by Mr. Rankine Kennedy that since a screw propeller is effectively an aëroplane (or, rather, aërocurve) and *vice versâ*, an aëroplane is a propeller of infinite diameter, that since the gliding type of machine uses a combination of the two (propeller and plane), while the hélicoptère uses only the propeller, the latter must be more efficient mechanically and, therefore, preferable. The author does not feel able to accept this reasoning in its entirety, for two reasons:

(1) The area adaptable to the aëroplane is impossible in a propeller. (On the question of speed mention will be made later.)

(2) In the present state of aërodromics it does not follow that a machine which is more efficient (mechanically) than another is necessarily superior from a practical point of view. Thus the Farman machine is, mechanically, far less efficient than the Phillips machine, and yet the latter has not been so successful in its flights.

The comparison at present must be one of lifting effort, *not* efficiency. The two are not necessarily concurrent. If the propeller of the aëroplane can exert horizontally a thrust of, say, 10 lbs. per H.P. at its proper speed of advance and slip, and the aëroplane has a lift to drift ratio of 5, then a lift of 50 lbs. per H.P. follows necessarily, with an obvious superiority over a 40 lbs. lift per H.P. for the hélicoptère.

There is yet another question which arises in connection with the area, which has been referred to by Sir Hiram Maxim in his correspondence to "Engineering," viz., the importance of area as such. Many years ago Drs. Hutton and Robins found that resistance varies as some power of the area greater than unity. The work of Langley, Kummer, and Eiffel has shown that the greater the perimeter, the greater the pressure per square foot. Thus a circular area has the least coefficient of plane resistance, and a long narrow parallelogram approaches the maximum. Now, the perimeter of such figure increases more rapidly than the longer dimension. Thus a parallelogram 2 × 1 has a perimeter of 6 feet, but a parallelogram 4 × 1 has a perimeter of 10 feet, so that while the dimensions have increased in the mean ratio of $\sqrt{\frac{4}{2}} = 1.414$, the perimeter has increased in the ratio $\frac{10}{6} = 1.\dot{6}\dot{6}$.

A further most important consideration in propeller matters is the effect of one blade on the supply of air to others. As Professor Thurston and others have pointed out, the thrust diminishes if a propeller runs with its axis and plane of revolution stationary on account of the churning of the air, which reduces the relative velocity of the air. Again, a propeller in a cross stream of air gives more thrust than when there is no such current. Vogt has, the author believes, shown this experimentally. Furthermore, an advancing propeller does not lose thrust to the full extent that the slip would indicate, on account of the increased facilities for air supply. (See Appendix B.)

Applying this principle of facility of supply to the two types we may draw the following conclusions:

(1) An advancing aëroplane has a greater lift than a hélicoptère can obtain (identical propellers being used), since the copious supply of air maintains a thrust comparable with that on a stationary propeller.

(2) A stationary hélicoptère (in the absence of wind) will tend to lose ascensional force.

(3) A cross wind will increase the ascensional force on a hélicoptère, but will make the centre of pressure eccentric in each propeller. Such a wind will, of course, be produced by the mere motion of the machine, except when this motion is in the same direction and of the same magnitude as the wind.

(4) Shields round the propellers will destroy this cross draught effect, but will reduce lateral resistance and tend to keep ascensional force constant.

[Of this more below.]

Summarising the factors which determine the thrust of a propeller we may notice the following:

(1) **Area.**—Thrust varies directly as this, but also the rotational resistance varies with it.

(2) **Pitch.**—According to Eiffel's recent results 30° pitch angle (*i.e.*, mean pitch angle of blade, *not* maximum pitch angle) gives maximum reaction.

(3) **Diameter.** — Resistance and thrust vary as the square of this.

(4) **Speed.**—The thrust and resistance vary as the square of this item.

(5) **Slip.**—Thrust and resistance decrease with decrease of slip (*i.e.*, increase of actual advance).

(6) **Section of Blades.**—Stream line forms the chords of which lie in the direction of the pitch angle will give minimum resistance, and if of the Phillips concavo-convex type give a maximum lift to resistance ratio.

(7) **Smoothness of Blades.** — By making the surfaces of the blades polished, skin friction is almost eliminated.

(8) **Cross Draught.**—The thrust is increased by a quantity varying as the square of the cross draught velocity.

(9) **Advance.**—Do. do. do.

(10) **Number of Blades.** — Interference and churning increase with the number of blades.

(11) **Feed Tunnels.**—Destroy cross draught unless *horizontal* at inlet, but distribute pressure on propeller uniformly.

(12) **Discharge Tunnels.** — Reduce thrust unless short, diverging, and vertical.

Mr. Chree Brown's suggestion that there is a vortex about a propeller is noteworthy, and would undoubtedly serve to explain the effect of deficient air supply.

4.—LIFT AS THE PREDOMINATING FACTOR: MECHANICAL EFFICIENCY.

It has already been mentioned that, from the point of view of sustentation, the lifting force available is much more important than mechanical efficiency. There can be no denying that the majority of machines are very inefficient, and while every effort should be made to improve them in this respect, the mere fact of continuous support is a far more important criterion, seeing that upon this safety and dirigibility mainly depend. A brief consideration of mechanical efficiency in the two types will, however, be useful. In a hélicoptère of the usual type there are n vertical screws (n being some multiple of two), and m (1 or 2) horizontal screws. For constructional reasons and manipulation it is very difficult to avoid using separate motors for sustentation and propulsion, so that at least two motors, respectively for these two purposes, will be required. If these have powers H and H_2, and the weight of the whole appliance is W and the resistance at the maximum speed of translation is R, we may say that W must be less than 30 H_1 lbs., and R less than 20 H_2 lbs. These numbers are assumed for the following reasons:

(1) The usual maximum thrust in lbs. per H.P. is 40. (Kress's uncertain result of 80 odd lbs. is probably not easily realisable.) This will be appreciably reduced by the transmission mechanism and the n thrust blocks, so that 30 lbs. per H.P. is certainly not too low a figure to adopt.

(2) The thrust from the propulsive screw will diminish with the slip, so that taking into account gearing losses, 20 lbs. per H.P. is a high figure.

[It will be noticed that the author previously gave a much lower figure. He here assumes the fullest possible allowance for the effect of air supply occurring during translation.]

In each case the maximum derivable thrust is found by reducing the H.P. to foot lbs. per sec. by multiplying by 550 and dividing by the speed of advance, but as this may be zero in the case of sustentation without ascension the mechanical efficiency of the lifting screws is indeterminate. A crude comparison may be made by saying that in each second the weight is lifted $g/2 = 16.1$ feet, *i.e.*, the distance which it would fall during one second. In this case the efficiency works out to

$$\frac{W \times 16{\cdot}1}{\frac{W}{30} \times 550} = 0{\cdot}878.$$

Such a method of computing efficiency is mechanically false (as may be seen by assuming 40 lbs. per H.P. when the efficiency becomes more than unity), but is, perhaps, useful for purposes of comparison. As a matter of fact, no work is performed in lifting if there is simple sustentation, the energy absorbed by the propeller being actually all given to the air, the lifting force being the reaction or rate of change of the momentum of the air.

As regards the propulsion, the efficiency will probably be about 50 per cent. (see Langley's dynamometer-chronograph experiments), and in any case will only differ from that of an aëroplane's propeller as the result of the disturbing effect of the sustaining surfaces.

With regard to the efficiency of the aëroplane type, the thrust acting against the resistance multiplied by the speed of advance gives the useful work done, and this, divided by the actual work done on the propeller in the same time, gives the efficiency of the latter.

Under these circumstances the author fails to see that a simple comparison can be drawn between the efficiencies of the two types, and can only reiterate his opinion that lift per H.P. is the real criterion.

5.—SAFETY AND STABILITY.

The "Engineering" controversy originated in a discussion as to the safety of the aëroplane, and the author in a letter referred to Lord Rayleigh's analysis and the practical results obtained by Blèriot, Archdeacon, and others in free gliding. There seems to be no doubt that machines can be built which will be automatically stable when certain conditions as to poise, weight, and resistance are satisfied. There is no necessity now to consider this question, which has been pursued at length by Weiss and others. As regards the stability of the hélicoptère, as the author endeavoured to show in "The Problem of Flight," the equilibrium is practically neutral. Single-screwed hélicoptères would, it is true, have a certain stability on account of the moment of momentum of the propeller, but unless the weight of this were considerable or the speed very high it would seem unlikely that any great reserve of stability could be available. As to two-screwed hélicoptères, unless the axes were geared together as in the Brennan gyrostat, the gyroscopic effect would be zero, since to produce balance of pressure on the blades and prevent wheeling they must revolve in opposite directions.

By the use of independent gyroscopes or a differential gearing on the propeller shafts automatic balance in a hélicoptère is possible, but beyond this fact (which is equally true in regard to the aëroplane) the appliance has no necessary stability.

6.—RESISTANCE TO PROPULSION.

There is the further question of collapse when the engine stops accidentally. The parachute action of screws would not seem to be very reliable.

The question of propelling a hélicoptère has not, as far as the author is aware, received much attention. By forming the hull of an enclosed and stream line form the resistance of this part of the vessel may be reduced to a minimum, but

when we come to consider the propellers themselves serious difficulties arise. There can be little doubt that a revolving propeller laterally displaced causes considerable resistance. The mere fact that its thrust is increased would indicate a corresponding increase in the resistance overcome both by the screw itself and by the source of lateral motion. The author is endeavouring to ascertain the approximate value of this resistance, but he has no doubt whatever that it will be a most serious source of hindrance to propulsion.

The alternative is the enclosed propeller. If a casing of stream line form be placed round the propeller it will necessarily greatly decrease the lateral resistance, but, unfortunately, it seriously affects the propeller, as already mentioned, and it would seem inevitable that any form of screw shaft which endeavoured to take advantage of the cross draught (by horizontal openings or otherwise) would greatly increase lateral resistance and thereby reduce the maximum velocity attainable. It must further be considered that this lateral resistance, if reasonably high speeds are desired, will necessitate a powerful and, therefore, weighty propelling motor, the weight of which has to be sustained by the lifting screws, which again will need to be more highly powered.

From this point of view the hélicoptère is at a great disadvantage.

7.—SKEW HELICES.

The suggestion has several times been made that oblique screws to effect combined propulsion and sustentation might be employed. This is undoubtedly feasible, but is open to the following important objections:

(1) The sustentation should be obtained with a minimum power from the outset (*i.e.*, the maximum vertical thrust is required from each horse-power), and if oblique acting screws are used, only the vertical component of the thrust would sustain the load. The difference between the thrust and its vertical component, although usually small, would necessitate a serious increase in the weight of the motor. (The author is not prepared to say at present whether this increase is greater than that necessitated by the use of a separate propulsive motor.)

(2) Speed could only be obtained at the expense of lift, since if at all times the thrust is a maximum, as one component (the horizontal) increases, the other (vertical) decreases. Moreover, decrease of thrust would accompany the decrease of slip.

It should, perhaps, be here noted that the use of auxiliary aëroplanes in this connection would, perhaps, get over the difficulty.

(3) The constructional difficulties would be serious. It is true that the slewing (or skewing) axis might pass through, say, the driving shaft, and by the use of bevel gearing the mechanism would not be interfered with, but the arrangement will certainly be complex and, perhaps, dangerous. (See Appendix C.)

8.—ORTHOPTERIC ANALOGY.

The late Professor Pettigrew repeatedly expressed his opinion that the action of a wing was comparable with that of a screw propeller, and there has recently been a tendency with some experimenters and theorists to develop this idea. While the author has the greatest respect for Pettigrew's work, especially in the question of elasticity, he ventures to question the mechanical identity of the two mechanisms. Professor Marcy, who consistently opposed the English naturalist's view in this subject, certainly appears to have a better claim for consideration. Granting that a vibrating elastic wing is of helical *form*, it is not necessarily of the same action as a screw propeller. The argument adduced by the supporters of the idea is practically this: The wing, under the action of its inertia, the reaction of the air, and its elasticity, becomes helical in form and swings through an arc, acting as a screw. On the back stroke the helicoid surface changes hand, so that the action is continued in spite of the reversal of motion. As a matter of fact, an examination of Marcy's sphygmographic records show that there is no such defini' helical action. The wing truly twists during its cyclic period, but its action is throughout that of an aërocurve directed forward. The author is inclined to think that Mr. Turnbull, in his well-known paper to the "Physical Review," comes nearest the truth.

In any case the bird's wing is equally

adducible as a natural basis for an aëroplane as for the hélicoptère.

Finally, the author would wish to express his opinion that both types are well worthy of study, and that certainly neither of them is the final form of the flying machine.

APPENDICES TO PAPER ON HÉLICOPTÈRE *v.* AËROPLANE.

A.

Lord Rayleigh's comparison of the efficiencies of helix and aëroplane (Manchester Memoirs, Vol. xliv., 1899, No. 5).

Rapid flight of aëroplane.

$$U = \sqrt{\left(\frac{W \sin \alpha}{\kappa S}\right)}$$

Direct maintenance by screw rotating about a vertical axis.

$$U = \sqrt{\left(\frac{W}{4 \rho S^1}\right)}$$

U = rate at which W must be lifted to do the work actually performed by the machine.
W = weight.
α = angle of elevation of aëroplane.
ρ = density of air.
S = area of aëroplane.
S^1 = disc area of propeller.
κ = resistance of unit area of aëroplane moving directly normal to current at unit velocity.

The ratio of the values of

$$U = 2 \sqrt{\left(\frac{\rho \sin \alpha}{\kappa} \cdot \frac{S^1}{S}\right)}$$

Taking $\kappa = .0024$ and $\rho = .0012$ (metric units) the ratio $= \sqrt{(2 \sin \alpha \, S^1/S)}$

"Since α may be made small, and S the area of the plane may be a large multiple of S^1 the area swept over by the screw, it would appear that the advantage must lie with the aëroplane, even if the object be mere maintenance, and not a rapid transit from place to place."

B.

EFFECT OF CROSS DRAUGHT ON SCREW PROPELLER.

(After CHREE BROWN.)

If α be the velocity of the screw at any point, in the absence of wind, thrust $\propto \alpha^2$.

If there is a cross wind of velocity β, then on one side of the screw the thrust varies as $(\alpha + \beta)^2$ and on the other side, thrust varies as $(\alpha - \beta)^2$. The total thrust, therefore, varies as

$$\{(\alpha + \beta)^2 + (\alpha - \beta)^2\} = (2\alpha^2 + 2\beta^2)$$

i.e., thrust varies as the sum of the squares of the screw velocity and the wind velocity.

Strictly speaking, the summation should not be taken at the two sides, but over the whole disc area, *i.e.*,

Thrust varies as $\Sigma_0^{2\pi}$ (vector sum of α and β)^2.

Mr. Brown's reasoning is, nevertheless, substantially correct, and there is no necessity to introduce a complex integral here.

C.

SKEW HELICES.

If the thrust be taken for any one screw as Cn^2, where C is a constant and n are the revolutions per unit time, it will necessarily follow that if n is a maximum (as determined by the resistance to rotation, which is practically independent of rotation), the lift when the axis is inclined to the angle θ, the vertical lift will be $Cn^2 \sin \theta$ and the horizontal force $Cn^2 \cos \theta$. Since $\sin \theta$ is less than 1, and when simply sustaining $Cn^2 = W$, the weight, when θ exists, Cn^2 is less than W and the weight is not sustained. If n is increased more power is required to overcome the rotational resistance.

THE LATE MR. F. H. WENHAM, HON. MEMBER OF THE AËRONAUTICAL SOCIETY OF GREAT BRITAIN.

Members of the Society will hear with great regret of the death of Mr. F. H. Wenham, one of its Hon. Members.

Mr. Wenham was one of the leading members of the Society at its foundation, and may almost be called the "father" of aëronautics in this country. His paper on "Aërial Navigation (1866)" is one of the most important ever published on aëronautical science, and contains a a great deal of most valuable information.

It should be specially noticed that he was the first to advocate the superposed planes now used by Farman, the Messrs. Wright, and others, and there can be no question that his idea of reducing the great width required for support by placing narrow supporting surfaces one above the other is one that has been most helpful to aviators.

Mr. Wenham always took a great interest in the Society, though his health of late years prevented his doing much active aëronautical work. The paper by him, published below, appears to be almost, if not quite, his last contribution to Aëronautical Science.

On the Construction of Detailed Parts of Aeroplane Flying Machines.

By F. H. WENHAM (Honorary Member).

(See Fig. 3.)

I write promptly on this very important subject, as time with me is on the wing. I have passed fourteen years beyond the three score and ten of life allotted to man. For many years I have at times brought up the subject of flying, and if I say a few words concerning myself I may, perhaps, be exempt for incurring a charge of egotism.

My training has been that of a marine engineer. I was present at the early trials of "Archimides"—the only screw steamer then afloat. I was but a small boy then, but ever since have taken a keen interest in screw propulsion. It may, therefore, be asked why I did not apply a screw propeller to my design of a flying machine in 1866, but no motive power except steam was then known, and I could not imagine the practicability of carrying a supply of water and fuel up in the air and therefore had to consider the possibility of the strength of a man being sufficient to propel the machine. For this purpose the adaptation of a screw propeller was *not* feasible, as the man, having other matters requiring his attention, could not be solely occupied in turning a winch-handle. I, therefore, proposed to adapt a pair of oars to be worked by treadles.

No rudder would be required, each oar being independent of the other, and could be manipulated singly. I am still inclined to believe that an active man of light weight could fly short distances by his own muscular exertion.

The power consumed in driving the recent flying machines is enormous, but by studying and improving every detail this may be much reduced.

Either for propulsion or sustentation in air flat surfaces are not as efficient as hollow curvatures, which from the upward pressure or lift on the air on the fabric take this form—perhaps not correct, but sufficiently near as not to be worth while to shape to a curve—the number of transverse ribs as weight and aërial resistance is so detrimental. Smooth surfaces are most effective. I have obtained the best results in models by using thin tinplate, but for large surfaces metal is impracticable. Thin glaced holland is suitable for the webs, but it must be rendered hygroscopic or the successful flight of one day may be a failure the next, caused by the flaccidity of the web from the absorption of moisture; the fabric should, therefore, be varnished. There is no extra resistance from cutting a long stretch of fabric across in short lengths and superposing them in sections. The power for propulsion is the same, and we have the advantage of an arrangement in manageable compass. It is just worth while to make the wooden rods for distancing the webs oval for diminishing forward resistance.

For the purpose of starting for a rise it seems imperative that the machine should first run over the ground on three wheels attached beneath. These will probably be smashed up by the shock of the first descent, thereby crippling the machine for another rise. These wheels should be without spokes, or as disc or flange-wheels of vulcanised rubber, which on alighting may be crumpled up. They will serve as buffers against the shock of the fall, but regain their form. They should be as small in diameter as available, as they have to be carried as dead weight.

Next as to the important consideration of the screw for propulsion. Some inventors seem to consider the form of this to be of little consequence, and think anything will do, and figure discursive shapes, from a butter patter to a smoke-jack fan, whereas correct form is of the *very greatest importance*, as the screw is the recipient of the whole force of the engine, and should in no part be a drag on itself from malformation. Any defect of figure will cause great loss of force and propulsive effect, which must be strictly economised. Woven fabric is very insufficient for screw blades, as no permanent or correct form can be given to such a material. Aluminium sheet

would be perfect, but the difficulty of construction would be prohibitive.

Large screw propellers for ocean steamers are not cast from wood patterns, but the moulds are "strickled" up either in loam or sand, a practice well known to foundrymen. The strickle is guided by a tinplate fixed at the periphery.

Various experimental screws that I have made for the purpose of ascertaining the best form for propulsion were cast in gunmetal from wooden patterns, in themselves a suitable material and form for aërial propulsion. The block of wood glued up in pieces to a rough shape for a two-bladed screw, each one-sixth of the circle, was turned and trimmed at the extremity of the blades to a circle of the required diameter, and the sides made flat and parallel, with the centre, which was bushed with a brass tube, to slide freely on a turned iron rod held firmly between centres. The block was laid on a plain surface and the pitch with its curvature marked with a pencil on the ends for the blades from a card tinplate, and the same operation repeated exactly on the opposite side. The wood was then pared away down to each pencil mark to a narrow ledge as a guiding line for a fixed round-ended tracer, against which the ledge on the pattern was pressed, while a rapidly rotating drill-ended cutter of the twist form pared away the wood towards the axis in narrow zones, which were afterwards rasped down to a smooth face. Care must be taken that the double-edge cutter must at the end be the same in size and outline as the end of the guide pin. The traverse of the cutter was not directed as a straight line towards the axis, as the screw blades require to have a disked form in their outline in order to utilise the radial force of centrifugal action. A perfectly plain smooth disc in rapid rotation will throw off centrifugally a current of air. This we utilise by the disked form of the screw. For this radial curvature I have at present no formula; it is merely empirical, and assumed on mere judgment, and is something like a curved line from the inside of a saucer. This duplication of cross curves may appear very formidable, and difficult to the constructor of aërial machinery, but is, in fact, a very easy piece of work. The slip or yield of the air will be about 25 per cent., therefore the curve of the air blade must end in that ratio, starting from a pitch equal to the diameter.

First build up a pedestal in cement to the diameter of the screw laid off on opposite sides to one-sixth of the circle. Two templates will be required, one of them of thin sheet-iron lined out for the entering angle with expanding the pitch of the screw, and the sheet cut to this line; the other or radial template, or "strickle," is swung from a fixed vertical central rod. From this "strickle," guided by the edge of the sheet-iron template bent to the circle of the screw, a plasterer can form up the face of the screw blades in hard drying cement, the same on both sides for each blade. This forms the mould for the wooden screw. This is made up of layers of veneer of any suitable kind of wood. These are steamed or soaked in water to render them pliable. The faces of the mould are first covered with paper to absorb any exuding glue, and the veneer laid on. Another veneer glued over is laid on this somewhat diagonally in order to cross the grain, and in this way a thickness of several layers may be added as required. This will make a very strong and tough construction of blade. The central boss should be built up and strengthened by two iron hoops and bushed with a metal tube. I trust that these directions are comprehensive, but any skilled cabinet maker knows the work of veneering.

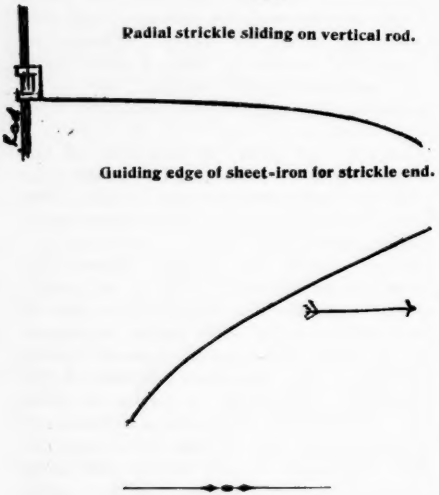
The back of the blade may be strengthened by a longitudinal rib. The glue is to be made rather too thick for working, and then be thinned with strong acetic or chromic acid; this will cause the glue to be waterproof. When dry finish the smoothed blades with a coat of varnish.

The screw spindle should be placed in the flying machine exactly in the centre of effort or pressure; that is, air resistance above and below the axle should be balanced, as a skew thrust will cause a waste of power.

The diagram is an outline of the edge of the strickle and sheet-iron guide. There is a difficulty in making a comprehensive drawing of the complete screw propeller for the practical man. I therefore send a model made many years ago in a lathe and carved to form by a rotating cutter driven from the overhead

precisely by the method of template guides herein described. This form of screw enlarged, selected out of several that I made, when tried in my steam yacht gave most decidedly the best result and should be equally suitable as an air propeller.

Fig 3.



The Probable Cause of the Explosion of Count Zeppelin's Airship.

By Lt.-Col. Moedebeck.

After the tragic fate which befel Count Zeppelin's airship the question naturally arose how such an explosion was possible. The first supposition was that when repairing the defective motor a fire had been used under the balloon, and that as the latter was borne from its anchorages the escaping hydrogen was set alight by this fire. But examination proved that no such fire had been lighted. The two mechanics, Schwarz and Laburda, who were in the airship at the time of the disaster, as soon as they realised the violence of the hurricane and saw that the soldiers, owing to the anchorages having given way, could not hold the vessel down, did undoubtedly with great presence of mind open the valves, their object being to reduce the lifting power of the balloon and thus prevent its being blown away. But as there was no fire near, this action would not account for the explosion, for which there seems to be only one plausible reason, viz., the electrical ignition of the gas, although on this point opinions differ widely. In my opinion the following explains simply how the disaster occurred:

The balloon material, which is india-rubber coated, has the peculiar property of becoming electrified in dry air. When rolled up or creased in any way it rustles, and gives out electric sparks, the latter being (as shown by the experiments undertaken by Professor Bonsteim and Captain Dele for the Berlin Aëronautical Society) clearly visible in the dark.

Now, the lower parts of the material of which the gas cells are composed would, owing to the height to which the airship had ascended (1,100 m.) and the release of gas from the valves, become creased or folded upon each other, and the rubbing thus produced would be quite sufficient to generate the electric sparks above referred to. Under ordinary circumstances, when the space between the gas cells and the outer envelope of the airship is full of atmospheric air, continually renewed, as when it is in full flight, these sparks would be harmless enough, but when the ship is at anchor, as at Echterdingen, this is not necessarily the case.

We know that the carefully made tissue of the Continental Caoutchouc Company resists the penetration of hydrogen very strongly, but some may have leaked through into the space between the cells and the outer envelope, while it seems very probable that when the mechanics opened the valves and the long axis of the balloon became inclined, more hydrogen entered this space and an explosive mixture was formed.

According to the description given by eye-witnesses, the explosion took place after the fore part of the vessel (dragging its anchor) struck the ground. The shock thus caused would have been transmitted to the creased and wrinkled gas cells, and the tearing of the material, already in an electrified condition, might easily have generated sufficient sparks to detonate the explosive mixture.

It may be mentioned that this evil can be avoided in future.

On the Flying Fish.

By L. SHADBOLT, Esq., M.D.

I have been requested to write a short paper on the flight of the flying fish and the lessons which this act may afford in the steering and management of an aëroplane in flight.

As yet we are still striving to attain success in aërial flight by means of a machine heavier than air. Many remarkable flights have been recorded quite recently, and the art of aviation has advanced during the past few months by leaps and bounds. It now appears clear that under favourable conditions, still air, or with but a moderate wind and an open course, an aëroplane may be constructed, or soon will be, which can remain in the air as long as the motive power which drives the propeller is maintained, or practically as long as the supply of petrol capable of being carried holds out.

But we are far from mastering the art of aviation under varied conditions, of accurately balancing the machine in gusts of wind, of guiding it with precision, and executing sudden changes of course with safety. The enormous sail area also of the present machines render their management difficult and hazardous. There is much yet to learn in the relations of sail area to weight carried, the velocity necessary, and the angle at which the under side of the sails must impinge on the air, and so on. These data, as well as many more, and their relations one to another, require to be, as it were, fixed and formulated and made to co-ordinate.

The accurate observation of the flight of animate beings may afford many valuable hints towards the mastery of this difficult and complex subject. With this in view I believe that a few observations on the flight of the flying fish (*Escocoetus californiensis*) may prove of interest.

The flight of the flying fish is an act unique in Nature. It is, at least during the major part of its duration, a pure glide, and, therefore, more analogous to the flight of an aëroplane than the flight of any other creature. It is true that birds often glide, but the flight of birds is a more complex act in that they are all capable of imparting to their wings a vertical up and down motion known as "flapping." Flying fish do not flap their wings, which, as is well known, are modified pectoral fins. With the exception of a slight tremulous motion of the posterior segments of the fins during the first second or so of flight, they are held extended as long as the fish is in the air. There is, I believe, only one other creature in Nature whose flight is a pure glide. I refer to the flying squirrel of the Malay islands. In the case of this animal, however, the glide is always downwards. It is, I believe, incapable of a horizontal or upward motion while in the air.

Having made many long voyages in tropical and subtropical latitudes, I have had some opportunity of observing the habits and mode of flight of the flying fish.

The largest-sized flying fish I have actually handled weighed about one pound and measured exactly 16 inches in length. During a gale they sometimes fall upon the ship's deck in great numbers, especially at night. After stormy weather I have known the seamen to go round with buckets to collect them, so great a quantity strewed the decks. They are probably not capable of rising to the ordinary height of a ship's gunwale, but are carried up by the upward current of air caused by the wind impinging on the ship's side. I remember finding one morning after a gale an extremely small specimen, not exceeding half an inch in length, lying upon the poop deck, which was some 10 feet above the surface of the water, obviously carried to that height by an upward current of air, not by its own exertions.

On examining a fresh specimen the following points may be noted:

When the pectoral fins are fully extended the anterior margin of the fin is somewhat in advance of a line drawn horizontally through point C Fig. 1 at right angles to the long axis of the fish's body.

When the fins are extended thus and the fish is held belly downwards in its position during flight, it is found that no vertical movement is permitted in the anterior segment C of the fin. The joint is, so to speak, locked as far as vertical movement is concerned, and though it yields, to some extent, to forcible vertical movement, it is plain that the joint is not constructed for a movement simi-

lar to the flapping of the wings of a bird. When, then, the fin is extended, its anterior margin is practically immovable in a vertical direction.

It is otherwise with the posterior segments of the fin. These are capable of vertical movement, the greatest movement being permitted in the segment the most posterior, the range of vertical movement decreasing in each successive segment as the anterior joint is approached. The fish can thus raise or lower the posterior margin of the fin and so alter the angle at which the fin meets the air, at will. This angle I will term, for the purpose of clearness, the angle of incidence, being the angle at which the general plane of the fin is held to a horizontal line passing through the long axis of the fish's body. It is the angle at which the under surface of the fin impinges, or is incident, on the air.

Briefly the flight may be described as follows:

The fish always leaves the water obliquely and at a high velocity. I believe that the velocity during the first second or so of flight is increased by rapid undulatory movements of the posterior segments of the pectoral fins. I have certainly repeatedly observed a tremulous movement, always at the beginning of flight, but have failed by the eye to note whether the movement in question is one of the body, tail, or fins. I believe it to be of the posterior segments of the fins, for reasons which will presently appear. The fish leaves the water at a very acute angle, and the lower segment of the tail skims the surface of the water often for many yards before rising above it. The result is that a streak is caused on the surface of the water by the wake of the tail. The formation of this streak on the water is a conspicuous feature in the flight of the flying fish. It is clean and sharp, and to my mind proves (1) that the tail at that moment is not in vibration, and (2) nor is the body in vibration, as otherwise its movements would be imparted to the tail. The tremulous movement observed must be then in the fins, and from the anatomical structure of the fins already described it seems clear that it is the posterior segments of the latter which are in vibration during the first second or so of flight, which then, as already mentioned, becomes a pure glide.

The body of the fish is not perfectly horizontal during flight, but slightly inclined upwards towards the head. The lower segment of the tail is always held

Fig. 1.

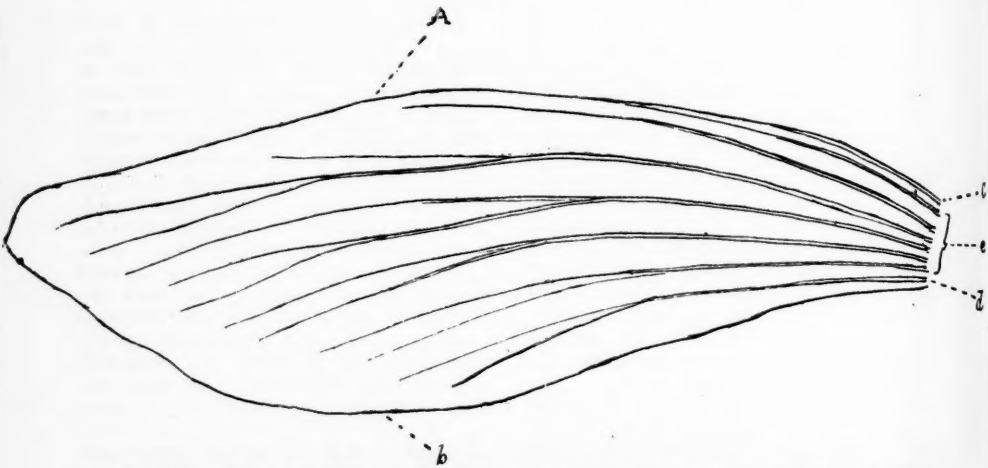


Fig. 1.—Outline of left pectoral fin of a Flying Fish, 9 inches in length, as seen from above. (*a*) Anterior margin. (*b*) Posterior margin. (*c*) Anterior bony segment. (*d*) Posterior bony segment. (*e*) Intermediate segments. From a specimen in South Kensington Museum. Natural size.

at a lower level than the body. Towards the end of flight this position becomes more marked, and the tail drops still further. The velocity varies, being greatest at the beginning of flight and least at the end. It is less than that of the stormy petrel or seagull. I would roughly estimate it at from 12 to 15 yards per second.

The position at which the pectoral fins are held when regarded *from above* is one slightly in advance of a horizontal line passing through the base of the fin at right angles with the fish's body. When regarded from *in front or behind* the tip of the fin is at a higher level than the base where it joins the body. When seen *from the side*, the angle, which I have termed the angle of incidence, varies with the velocity. At the commencement of the glide, when the velocity is greater, the fin, when regarded from this aspect is almost horizontal, the angle gradually becoming greater as the velocity lessens, until finally when the flight is almost exhausted it reaches nearly 45°. The maximum length of flight, I have observed, is some 200 yards.

These details can only be noted in the largest specimens and under the most favourable circumstances, when the distance is short, the light good, and the sea calm.

Finally, the tail again skims the surface for a yard or two before the fish ends its flight by falling in with a clumsy splash.

The flying fish is able to alter its course during flight, and when so doing always tilts laterally as in the case of a bird gliding in a horizontal curve, the fin on the outside of the curve described rising to a higher level than that on the inside. I believe that the curve is changed by the tail, not from actual observation, but from conjecture. The tail is of a peculiar structure (see Fig. 2), the lower segment being about twice the length of the upper. It has been seen that the tail during flight occupies a low position relative to the body of the fish, and becomes lowered still further towards the end of flight. This low position of the tail relative to the centre of gravity would cause on deflection the lateral tilt above referred to.

Some lessons, to my mind, which the aviator may learn from the flying fish is to employ a vertical rudder placed below as well as behind the centre of gravity, and one which can execute similar movements to those of which the tail of this creature is capable. I have proposed in a former paper a form of rudder answering partly to these requirements, the idea of which was first suggested to me by the tail of the flying fish.

Fig. 2.

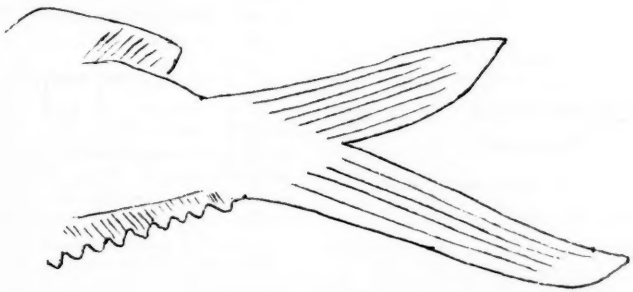


Fig. 2.—Outline of tail of Flying Fish. From same specimen. Natural size.

But there is much yet to learn of the flight of the flying fish beyond what these crude observations can supply. It is a model which may well be studied. Nature, in the course of ages, has relentlessly weeded out the unfit of all forms of life. She may often fail in producing a perfect individual, but in the type she is unerring. And Nature has produced and perfected myriads of types, each one the best of its kind for coping with the particular conditions with which it is sur-

rounded. Thus man may well turn to Nature for instruction and imitation, and in the complex and difficult subject of artificial flight Nature offers for his study a perfect model, the flying fish, from which he should learn much.

Note on the Farman Flying Machine.

By Col. J. D. Fullerton, R.E.

"Aëronautics" (U.S.A.), Aug., 1908, appears to have submitted the article published in this Journal, April, 1908, on the Farman Flying Machine, to Mr. Farman, who has made the following corrections:

I.—GENERAL DESCRIPTION.

(1) For canvas read "Continental rubber cloth."

(4) For 12° read "8°."

(5) For 12° read "8°."

(8) For 12° read "18°."

The Wright Bros.' Flying Machine.

By Col. J. D. Fullerton, R.E.

(See Figs. 4, 5, and 6.)

The following account of this machine does not, of course, pretend to be accurate as to all the details, but it is hoped that the general description and sketches will be found useful to those who desire to study a very remarkable apparatus.

1.—GENERAL DESCRIPTION.

The machine consists of:

A.—A body.

B.—The sustaining surfaces.

C.—The apparatus for steering in a horizontal plane.

D.—The apparatus for steering in a vertical plane.

E.—The motor.

F.—The propellers.

G.—The radiator.

H.—The seats for passengers.

2.—MISCELLANEOUS INFORMATION.

The weight of the machine alone is 375 kilg. (826.7 lbs.); two passengers may be taken to weigh 150 kilg. (330.7 lbs.), hence the total weight, in order of march, is 525 kilg. (1,157.4 lbs.)

The approximate velocity when flying on a level course in still air is 42 miles per hour = 61.6 ft. per sec.

The area of the sustaining surfaces is 50 sq. m. (538.2 sq. ft.), and, consequently, the load is 10.5 kilg. per sq. metre (2.15 lbs. per sq. ft.). This assumes that all the weight is carried by the sustaining surfaces, but it is probable that a small portion of it is borne by the surfaces of the vertical steering apparatus.

When the full power of the motor is used the weight carried per H.P. is 21 kilg. (46.3 lbs.), but probably only a part of the power is necessary for level flight. Exactly how much is required is not known, but some accounts state that Mr. Wilbur Wright only uses about 15 H.P. This would make the weight carried per H.P. 38.3 kilg. (84.7 lbs.). A very good performance. The "gliding angle" is about 5°.

3.—THE BODY—A.

This consists of two curved frames shaped something like skates. The lower sustaining surface rests upon them, and the fronts form standards for the surfaces for steering in a vertical plane.

The body is made of wood (spruce) except at the joints, which are of steel.

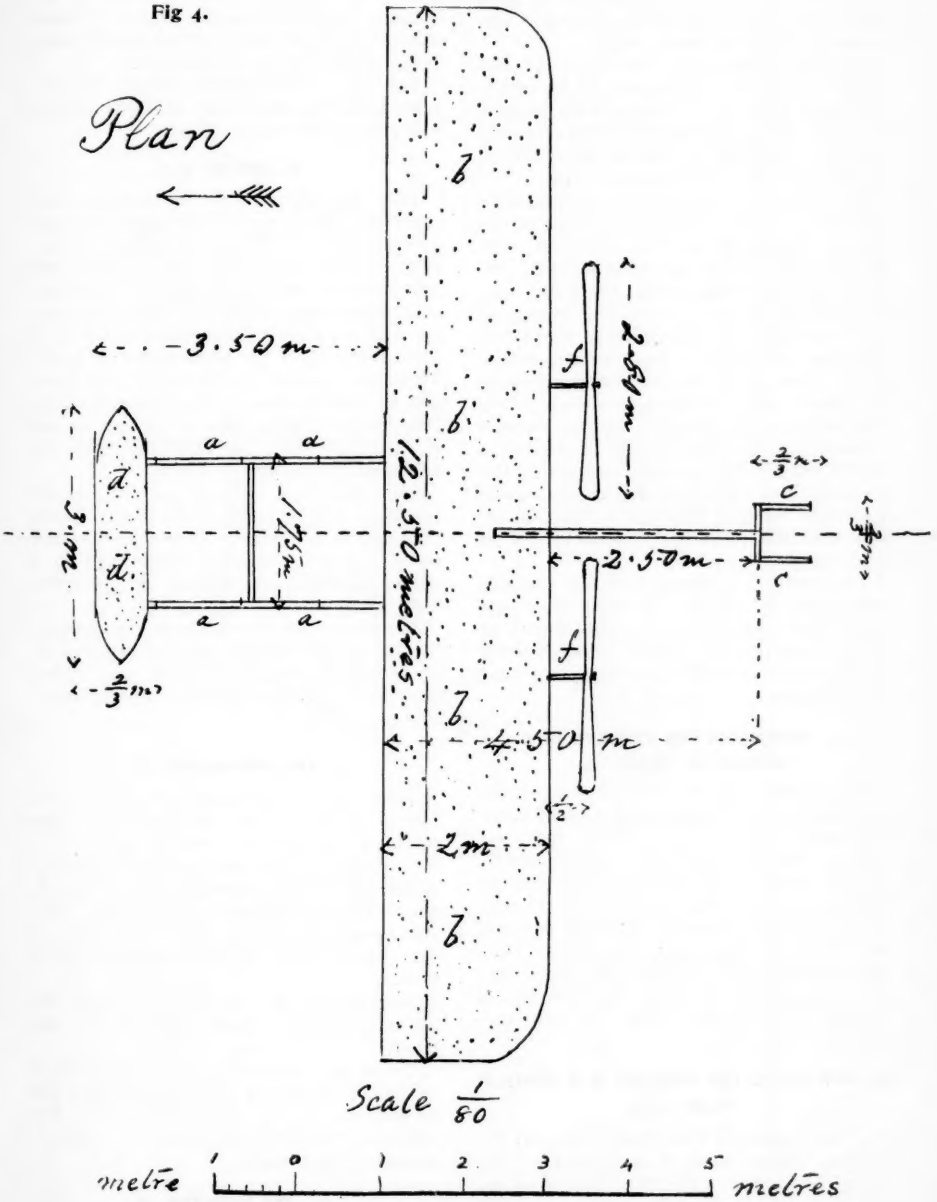
The angle between the straight or rear portion of the skates and the chord of the arc of the section of the sustainers is about 5°, and the "gliding angle" appears to be about the same.

The passengers sit upon two stools placed upon the front portion of the lower sustainers (see H.H.), their weights being so arranged as to balance the weights of the motor, radiator, etc.

4.—THE SUSTAINERS—B.B.

There are two sustainers, each 12.5 m. by 2 m. wide, the two having an area of 50 sq. m. (538.2 sq. ft.) The framework is constructed of American spruce wood, and consists mainly of two 1¼-inch sq. stringers about 4 feet apart, running the whole length of the sustainers, and cross pieces at right angles to them. The whole is covered with canvas, the rear edge of which is strengthened by iron wire. In section the sustainers are said to be of the buzzard's wing type, but are apparently only slightly concave on the

Fig 4.


Plan
3·50 m
2·50 m
1·75 m
2·50 m
2 m
1·50 metres
Scale 1/80
metre
0 1 2 3 4 5
metres

underside. The arching appears to be about $\frac{1}{20}$m., or about 4 inches in a width of 2 metres, the greatest height being at a point about one-third of the length of the sustainer from its front edge.

The chief features, however, of the sustainers are the arrangements by which the outer portions of each can be warped so as to vary their angles of inclination, and the method by which they act in unison with the rear rudders C.C.

The system is somewhat complicated, and is best understood by studying the Patent Specifications, but briefly, if, say, the left side of the machine is from any cause pressed downwards, the pilot can, by suitable levers, cause the marginal and rear edges of that side to rise (thus reducing its angle of inclination), while, at the same time, the similar portions of the other side, working in unison, fall. This restores the balance, but as there is a tendency for the whole machine to rotate round its longitudinal axis, the vertical rear rudders C.C. are automatically brought into play, with the result that the machine is held on to its true course.

The vertical distance between the two sustainers is 1.8 m. (6 ft.); they are connected together by uprights about $1\frac{3}{4}$ inches in diameter, further support being given by a system of cross wires between the uprights.

5.—APPARATUS FOR STEERING IN A HORIZONTAL PLANE—C.

This really consists of two parts in the rear rudders C.C. (two) and a small vertical rudder fixed in D. These work together, and the pilot can, consequently, see the angle of inclination of C. without turning round. The rudders C.C. consist of flat surfaces (canvas on wood frames) each 1.80 m. high and $\frac{2}{3}$ m. wide. They are worked by a system of levers, the general method of using them being, of course, exactly the same as that employed in sea-ships.

6.—APPARATUS FOR STEERING IN A VERTICAL PLANE—D.D.

This consists of two small planes D.D., oval in shape, each 3 m. long by $\frac{2}{3}$ m. wide; total area of the two about 4 sq. m. (43.05 sq. ft.). The planes rotate in unison round an axis fixed on the standards formed by the ends of the skate-like ends of the body frames, and can be set, by a system of levers, at any required angle. Ascent or descent is carried out by increasing or decreasing the angles of these planes, and the longitudinal equilibrium is maintained in a similar way.

The use of the small vertical rudder, 1 m. high, in the centre of these planes has already been described.

7.—MOTOR—E.

This, like the rest of the machine, has been designed by the Messrs. Wright themselves. It is a 4-cylinder 25-27 H.P. motor; bore 108 mm., stroke 100 mm., water-cooled, magneto ignition, with automatic valves. The cylinders are cast separately, the water jacket is of aluminium, and no carburettor is used. The bare weight is 70 kilg., the total weight with radiator, etc., being 90 kilg. (198 lbs.). The weight of the engine per H.P. is 3.6 kilg., or 7.92 lbs. The revolutions per minute = 1,650.

The motor is placed on the lower sustainer a little to the right of the centre line of the machine. Petrol is supplied from a long cylindrical tank fixed in a handy position to one of the uprights connecting the two sustainers.

The power of the motor is transmitted to the propellers by chains running in guide tubes, the left-hand one being crossed to give the opposite movement to the propeller.

8.—THE PROPELLERS—F.F.

There are two 2-bladed propellers each 2.8 m. (9 ft. 4 ins.) in diameter. The pitch is not known, but is said to be rather large. The pitch angle is probably about 24°. The propellers are of wood, make 450 revolutions per minute, suitable gearing reducing the revolutions of the engine shaft in the proportion of 33 to 9.

The thrust line is at 1 m. aboye the lower sustainer; ball bearings are not used.

There are no details to be obtained as to the actual thrust of the propellers, but it appears to be about 100 lbs. The efficiency of the propellers is approximately 75 per cent.

9.—THE RADIATOR—C.

This is attached to one of the uprights connecting the two sustainers. No de-

Fig 5. Section on Centre Line.

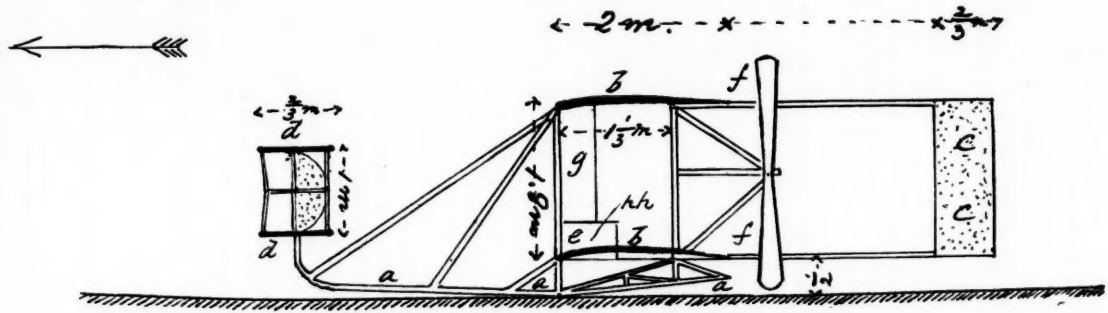
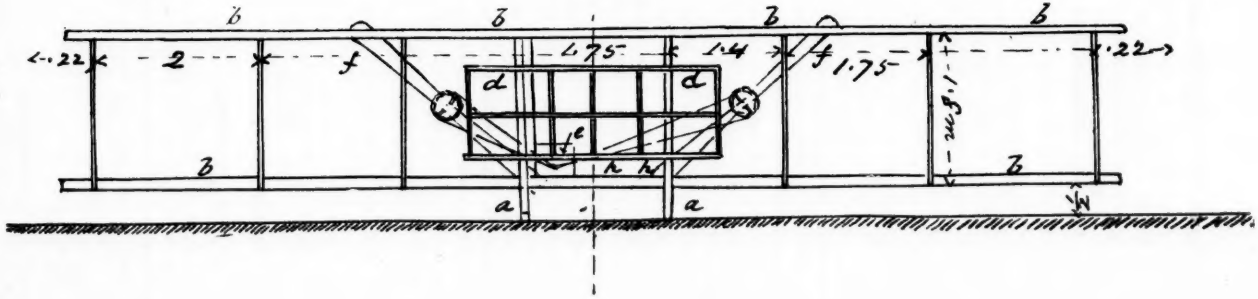


Fig 6. Front Elevation.



tails regarding it are available, but it appears to consist of about 36 ft. of copper tubing.

10.—SEATS FOR PASSENGERS—H.H.

These have already been alluded to. Footrests fixed to the front edge of the lower sustainer are provided.

11.—STARTING ARRANGEMENTS.

The machine can be started in three different ways:

1st. By placing it on a small carriage and running it along a level, smooth piece of ground under its own power. It is reported to rise in the air after a distance of 250 m. (820.2 ft.) has been traversed.

2nd. When there is a fair amount of wind (velocity not given) the machine is run along a wooden rail some 25 m. long, under its own power, and rises in a distance of about 20 m. The rail is movable, and can be fixed up so as to enable the machine to face the wind when starting. A groove in the machine body fits into the head of the wooden rail.

3rd. In calm weather the necessary extra impetus is given by a sort of catapult arrangement, consisting of a heavy weight 700 kilg. (1,520 lbs.) and a cable, one end of which is attached to the weight, and the other to a catch on the front of the machine. When it is desired to start, the propellers are put in action, and the weight dropped; the combined thrust thus produced drives the machine along the rail and the release of the catch after some 20 m. has been traversed causes it to sail away in the air.

There does not seem to be any difficulty in starting the machine by any of these methods. The second is, of course, the most favourable.

12.—ALIGHTING.

This is done by shutting off the power in the air and letting the machine slide down at a gentle slope. It appears to be quite easy, especially if the ground is smooth and level. Alighting on the skate-like runners does not seem to have given any trouble.

13.—REMARKS.

There is no doubt that this machine is by far the most successful one that has appeared so far. It has its faults, but taking its performances as a whole, no machine at present under trial can compare with it. The principal points to note about it are:

A.—The Body.

This, contrary to the French usage, has no starting wheels, and the machine rises in the air by means of its skate-like runners. For small, fast-flying military machines this would be a serious disadvantage, as they must undoubtedly be able to rise from any reasonably smooth, level piece of ground. There would not, however, be any difficulty in fitting wheels to these machines, and the Messrs. Wright are probably quite prepared to make such an alteration in their design.

As regards machines used for ordinary civilian purposes, wheels are not so important, as there is no doubt that some sort of land harbours, such as those advocated by Mr. Weiss in the "Aeronautical Journal" for January, 1908, will be found necessary, and as these would, of course, be supplied with all starting and alighting requirements, the question of starting wheels would be one of very minor importance.

B.—The Sustainers.

The main feature of these is, of course, the flexible arrangement for maintaining the equilibrium. This appears to work well in the hands of an experienced pilot like Mr. Wright, but it must be confessed that the system seems somewhat complicated and difficult to work. Only comparatively small alterations in the shape and inclination of the surfaces can be made, and the system, as a whole, appears to be too rigid and unsuited to any but small and slow changes of air pressure. Several accidents have already occurred on landing, which would probably not have happened had the crosswise equilibrium arrangements been modelled more on those of a bird. Whether this design is likely to be generally adopted remains to be seen, but in all probability it will, in future machines, be very considerably modified.

D.—The Apparatus for Steering in a Vertical Plane.

This appears to work well, and some such arrangement is, of course, necessary

for all except small machines. The longitudinal balance obtained by this method is, however, very delicate, and seems to require constant attention.

This is apparently due, not so much to the steering apparatus, as to the peculiar design of the machine as a whole.

E.—The Motor.

The motor seems to work satisfactorily and stands a good deal of knocking about very well. It can probably develop about 32 H.P. as a maximum, but the power used in the ordinary flights is evidently very much less; say about 15 H.P.

This fact does not seem to be quite appreciated. Comparisons are constantly made between the weight carried per H.P. in the earlier machines and the 84.7 lbs. per H.P. carried by this one. But such comparisons are fallacious, as the powers given for the earlier machines are the maxima which the motors were able to develop, *and not the actual powers expended*, as can easily be seen from the results obtained with the early gliders.

The newest Wright machines are almost exact copies of the gliders, the only differences being increased size and the additions of a motor and extra passenger.

Now, the gliding angles of the gliders was about 5°, say $\frac{1}{12}$, and, assuming the same value for the present machines, the

$$\text{H.P.} = \frac{\frac{1}{12} \times 61.6 \times 1157}{550} = 10.8 \text{ lbs.}$$

which is the net H.P. required to propel the machine at 42 miles per hour. Assuming the efficiency to be .75, the actual B.H.P.

$$= \tfrac{4}{3} \times 10.8 = 14.4 \text{ H.P.}$$

(and this is probably a fair estimate of the capabilities of the present flyer).

The balance of the power provided is for the extra work to be done when ascending, and to cover contingencies such as defects in motor, loss by gearing down, etc., etc.

F.—The Propellers.

With so few details concerning them it is impossible to calculate the power developed, etc. They, however, appear to be very efficient, and this efficiency is due to the fact that the Messrs. Wright have realised Langley's saying, that the best propeller is not the one which drives the largest amount of air to the rear, but the one which, so to speak, glides at the smallest possible angle to its path, and, consequently, puts the smallest possible amount of air in motion. The blades of propellers are, so to speak, "flying surfaces" moving along certain courses, and, like the ordinary sustainers, should make the smallest possible angle with their true course in order to reduce the power required to drive them.

CONCLUSION.

The other details do not call for much comment. It only now remains to congratulate the Messrs. Wright on the splendid work done by them, and to wish them every success in their future experiments.

NOTE.

Members of the Society will hear with much regret that shortly after the above paper was completed a very serious accident occurred when Mr. Orville Wright and Lt. Lahm, U.S. Army, were practising circular flights. On September 17th, 1908, the two were in the air at a height of about 75 ft., when one of the propeller blades broke, and though Mr. Wright did his best to guide the machine, it dived forwards and struck the ground with considerable velocity. Both aëronauts were injured; Lt. Lahm, unfortunately, so seriously that he died shortly afterwards, while Mr. Wright was much bruised and knocked about. Lt. Lahm was a most skilful aëronaut, and his death is a great loss to American Aëronautical Science. Mr. Wright is reported to be progressing favourably, and it is hoped that he will be able to continue his experiments later on.

Miscellaneous Notes.

THE ARMY AEROPLANE.

A second series of trials with the new military aëroplane was held on Laffan's Plain yesterday and was witnessed by Col. Capper, Mr. Cody, and a large number of the Balloon Factory Staff. The machine was wheeled from the balloon shed at Farnborough by a party of Royal Engineers. When the plain was reached Mr. Cody took his place in the centre compartment, and the propellers were set in motion. Apparently no attempt was made to rise from the ground, but three runs of from one-half to three-quarters of a mile

were made at a very fair pace. The experiments were repeated again in the afternoon.

The aëroplane appears to consist of two horizontal parallel canvas planes some 40 ft. long by 20 ft. in depth. They are connected by rods of about 7 ft. in length, which give the structure the appearance of the roofed upper deck of a house-boat. From the rear projects a huge fantail of canvas, which in turn supports a canvas rudder. From the front a projecting canvas plane balances the tail at the back. The motor and propellers, which resemble those attached to the old military dirigible balloon, are housed amidships within the canvas structure, and the whole machine runs upon light cycle wheels.

Another correspondent writes:

In appearance Mr. Cody's aëroplane from a distance bears a marked resemblance to the Wright machine, consisting of two canvas surfaces about 40 ft. long and 7 ft. wide, one vertically above the other, and, roughly, 8 ft. apart, the canvas being stretched over a light framework of wood and metal. Attached to the extremities of the lower plane are two small horizontal planes or rudders, while a third small vertical plane is fixed over the centre of the upper plane.

The tail-piece and principal rudder are behind the main body of the machine, and a horizontal plane or rudder is rigged out on two arms in front of the centre, by which the course can be inclined upwards or downwards. The small end planes and the vertical central plane are used in conjunction with the main rudder when turning to right or left, the inner plane on the turn being depressed, while the outer one is correspondingly raised, the vertical plane working in connection with them and assisting to preserve stability. The machine will turn far more readily if slightly tilted inwards—as can be noticed when a bird turns in its flight—than if kept in the horizontal position, and this important fact has been dealt with, I think, more efficiently by Mr. Cody's method than by that of the Wright Brothers, whose entire planes on right and left of the centre are slightly raised and lowered on opposite sides when turning. This naturally destroys the rigidity and solidity of the whole structure. In front of Mr. Cody on the lower plane is the motor—which, I understand, is a light type of 8-cylinder Antoinette—and on each side of him are the double-bladed propellers.

Further trials will in all probability be carried out at Farnborough before the aëroplane is transported to Scotland, where secret tests were in progress for some weeks last year upon a machine designed by Lieutenant J. W. Dunne.—"The Times," September 25th, 1908.

FARNBOROUGH, September 26th.

The tests of the new aëroplane, which has been designed and constructed here by Mr. Cody, in the military balloon factory, are to be carried out on the same system of gradual progression that has so wisely been adopted by Colonel Capper in his trials of the "Nulli Secundus." I am informed that there is no idea of attempting any aërial flight for the present, and, to quote Colonel Capper's own words, "only preliminary experiments are now being made, with a view to finding out the elements of balance and of control, so that anyone expecting to see anything at all sensational in the flying line will be greatly disappointed."

For this large craft to career about the ground on light wheels at about 20 miles an hour, considerable space is required, and in the interests of public safety this is doubtless the reason why spectators were kept so far from the machine by the mounted police on Friday last.

Any sudden deviation from her intended course would involve almost certain collisions and probable disaster to onlookers who were close to her, and, therefore, it seems highly desirable that Laffan's Plain, Hove Common, or whatever place is selected for further trials, be given a wide berth by those anxious to see our newest aërostat, both for their own safety and in order to give Colonel Capper and his staff as free a space as possible in which to carry out these early experiments.

At a later date, when practice in steering, balancing, and general control has been obtained, and new propellers suitable for aërial flight have been fitted and tested, opportunities will doubtless frequently occur for the public to see Mr. Cody and other officers manœuvring the craft in mid-air.—"The Times," September 28th, 1908.

Further trials of the military aëroplane were made at Farnborough last evening. The machine was towed to Farnborough Common about 5 o'clock by sappers of the Royal Engineers, and after a few minutes of preparation Mr. Cody mounted to the steering seat. Several runs, ranging from a quarter to half a mile, were made, in which the aëroplane appeared to answer her helm perfectly. After the final run home Mr. Cody declared that during his last trip for something like a hundred yards there was an entire absence of vibration, and he surmised, therefore, that the aëroplane must have lifted. Returning along the clearly-marked track of the wheels, Mr. Cody and an officer discovered a sudden cessation of the track for a measured distance of 78 yards. Several spectators standing near declared that the aëroplane lifted from the ground for some distance. Mr. Cody, however, attached no importance to the circumstance, which he said was, after all, only a jump. He declared further that with the present propellers he will not attempt anything in the nature of a flight. But when he has thoroughly mastered the steering, he says that much larger and more powerful propellers will

be fitted to the aëroplane for the purpose of flight.—"The Times," September 30th, 1908.

AERIAL NAVIGATION.

Successes of Mr. Wilbur Wright.

LE MANS, September 28th.

This afternoon and evening, in perfect weather conditions and in the presence of many well-known aëronauts, including Mr. Frank Butler, Mr. Percival Spencer, the Comte de Lambert, M. Paul Jamin, and others, Mr. Wilbur Wright gave a very fine demonstration of his flying powers. After his usual deliberate examination of his machine, he started at about 2.45 and flew 1 hr. 7 mins. 24 4-5 secs. Of this time only 1 h. 7 mins. 11 2-5 secs. counts for the Aëro Club cup competition, but during the latter period he covered 48 kilometres 120 metres, thus raising the achievement of last week by about nine kilometres. When he alighted about 20 yards from the turning post where I was standing, he explained that owing to the too free working of the lubrication pump he had run out of lubricating oil. "Otherwise," he said, "I could have gone on for two or three hours."

Mr. Wright's habit is to speak the truth, and, indeed, so perfect is his control of the machine in a light breeze, such as prevailed this afternoon, and so regular the working of his motor, that there appeared no reason why he should not have continued flying so long as any petrol remained in his tank. He lost no water during the flight, and did not vary his speed more than a second or two per kilometre in 10 kilometres.

Next Mr. Wright took as passenger M. Tissandier, whose father distinguished himself as a balloonist during the siege of Paris. It was now dead calm, but the flight was, in some respects, more impressive than the preceding one. The machine flew higher, frequently attaining 45 ft., and with the steadiness of a train. The speed was the same as before—namely, nearly a kilometre a minute. The flight lasted 11 mins. 35 2-5 secs., beating Mr. Orville Wright's "record" with a passenger by 2 mins. 19 2-5 secs. M. Tissandier had little enough to say about his "sensations." "I tried," he explained, "to have some, but there were not any, except," he added, "that of absolute safety." He had driven me out to the ground at a speed slightly exceeding 60 miles an hour, so he is probably somewhat impervious, but his experience tallies with that of his two predecessors, the brothers Zens.

Mr. Wright's next record was to carry a second passenger in one day in the person of the Comte de Lambert. The flight was equally uneventful, and lasted 7 mins. 15 secs. By this time the sight of the great beast wheeling its droning flight against the sunset had become almost commonplace—so quickly does the extraordinary become familiar.—"The Times," September 29th, 1908.

HYDROGEN FOR FILLING BALLOONS.

According to M. Mouricheau-Beaupré's communication to the Académie des Sciences, the following simple method of preparing hydrogen for filling balloons is available. An intimate mixture is made of finely divided aluminium with powdered bichloride of mercury and sulpho-cyanide of potassium. When water is added to this powder there is a violent evolution of hydrogen gas, which can be regulated by the volume of water employed, so as to keep the temperature down to moderate limits.—"The Times," September 30th, 1908.

Foreign Aëronautical Publications.

(In this list a selection of some of the more notable articles only is given.)

L'Aerophile.

July 1st, 1908.—The Dirigible "République."—Zeppelin IV.—The Dirigible "Italia."—The Wright Brothers.—Trials of Bleriot VIII.—On the Soaring of Birds.

July 15th, 1908.—French Aviators Abroad.—Zeppelin IV.—Trials of the "White Wing."

August 1st, 1908.—Sailing Flight.—The Dufaux Aëroplane.—On the useful weight in Aëroplanes.—Cheap Hydrogen.—Study of Sailing Phenomena.—The Coefficient of Resistance of the Air.—A Mathematical Theory of the Aëroplane.

August 15th, 1908.—The Gyroplane "Breguet Richet, No. 2."—The Dynamics of Sailing Flight.—Zeppelin IV.—The First Flights of the Brothers Wright.

September 1st, 1908.—Vibrations and Aërial Screws.—Jet Propulsion and High Speed Aëroplanes.—The Gastambide-Mengin Aëroplane.—The French Dirigible "République."—German Dirigible Balloons.

September 15th, 1908.—The Messrs. Wright in France and America.—Flights by Delagrange.—Some Reflections on the Wright Aëroplane.—Bleriot VIII.—The "Luyties" Helicoptère.—Three New French Dirigibles.—The Dirigible "République."

Societa Aeronautica Italiana.

July, 1908.—Apparatus for the Study of Friction. — Aviation. — Dirigibles. — Scientific Chronicle.—Review of the Reviews.—Sporting Supplement.

Illustrierte Aeronautische Mitteilungen.

July 15th, 1908.—American Airships.—The Permanent International Commission of Aëronautics.—Varieties.

July 29th, 1908.—Stability of Motor Airships in a Vertical Plane.—Count von Zeppelin's Trials on July 14th, 1908.—The French War Airship "La République."—The Aërial Experiment Association. — Flight Experiments in Sweden.—The Phillips Flying Machine (extracted from the "AERONAUTICAL JOURNAL").

August 12th, 1908.—Count von Zeppelin's Experiments on August 4th and 5th, 1908.—Short Notices.—Flight Experiments in Sweden. —New Flying Experiments.

August 26th, 1908.—Accidents and Measures for Rescuing Airships.—Indiarubber or Varnished Balloons?—New Experiments with the Parseval Airship. — Capt. Ferber's Flying Machine No. IX.—New Flight Experiments,

September 9th, 1908.—The "Vacuum" Airship.—The Disaster at Echterdingen.—The "Malécot" Airship.—Is Sailing Flight by Man Possible?—New Flight Experiments.

September 23rd, 1908.—On Aërodynamical Flight.—On the Descent of Airships.—New Flight Experiments. — The Schrader Flying Apparatus.

WIENER LUFTSCHIFFER-ZEITUNG.

July, 1908.—The Farman and Delagrange Flights. — The "Von Zeppelin" Airship.—Notes.

August, 1908.—Trials of the "Zeppelin."—The Winning of the Armengaud Prize by M. Farman. — The German Army Balloon.—Notes.

September, 1908.—Count Zeppelin. — The Loss of Zeppelin IV.—Critical Articles on Zeppelin IV.—Zeppelin V.—Wilbur Wright Flies.—Notes.

AERONAUTICS.

July, 1908.—June Aëroplane Flights in America.—Aëronautics in Europe.—Aeronautics in Great Britain.—A Dirigible to Carry Three Passengers.

August, 1908.—Farman in America.—The Month Abroad.—The Stability of Aëroplanes. —Kite Manipulation and the Record Flight.

Applications for Patents.

(*Made in July, August, and September.*)

The following list of Applications for Patents connected with Aëronautics has been specially compiled for the AËRONAUTICAL JOURNAL by Messrs. BROMHEAD & Co., Patent Agents, 33, Cannon Street, London, E.C.

JULY.

13259. June 22nd. R. M. BALSTON. Improvements in or relating to flying machines.

13315. June 23rd. R. MCLEAN. Improved flying machine.

13529. June 25th. A. FILLING. Improvements in the construction of kites.

13809. June 30th. C. LORENZEN. Improved form of aerial machine.

13948. July 1st. C. A. CHAPPELL and M. KAY. Improvements in and relating to flying machines.

14013. July 2nd. J. R. SCANDLING. Improvements in and relating to flying machines.

14196. July 4th. E. E. KELWAY. Method of and improvements in apparatus for propelling and manœuvring ships and torpedoes, also applicable to airships and the like.

14327. July 6th. J. DEIXLER. Improved flying machine.

14596. July 9th. C. A. CHAPPELL. Improvements in and relating to flying machines.

AUGUST.

15924. July 27th. T. W. K. CLARKE. Improvements in aeronautical machines.

16153. July 30th. F. WOOD. Improvements in aerial and the like machines.

16250. July 31st. M STIGLER. Improvements in or relating to flying machines and the like.

16295. July 31st. C. A. PIM and STRANGE, and GRAHAM, LIMITED. Improvements in connection with vessels which require to be steered, or have their course altered, whilst travelling in the air, or in or on water, or on land.

16300. July 31st. I. O. TZIMBALISH. Improvements in and relating to airships and the like.

16541. August 5th. N. BLOOD. Improvements in or relating to flying machines.

16544. August 5th. J. E. PFEIL and R. REUTER. Improved arrangement of working surfaces for propellers, fan blades, steering and supporting surfaces for water and air vehicles and the like.

16606. August 6th. W. FRIESE-GREEN and THOS. FRIESE-GREEN. Improvements in and relating to air-cars or airships.

16607. August 6th. D. F. SHEARER. Improvements in or relating to flying machines.

16834. August 11th. A. PASFIELD. Cyclopane.

16842. August 11th. C. L. BOUSQUER. Improvements applicable to cycles, motor cars, motor engines, aeroplanes, and the like.

16868. August 11th. J. H. BROWNING. Airship without gas.

16926. August 12th. H. L. TODD and J. A. WYLIE. Improvements in airships.

16941. August 12th. E. M. LINDHOIST. Driving device for boats, flying machines and the like.

17037. August 13th. J. LYLE. Improvements in means and apparatus for rising into and traversing the atmosphere.

17107. R. SCHWARZ and F. W. WEBER. Bird-like flying machine.

17131. August 14th. F. L. BARTELT. Improvements in apparatus for aerial propulsion.

17150. August 14th. J. WEISS. Improvements in and relating to bird-shaped aeroplanes.

17169. August 15th. W. E. HITCH. Improvements in or relating to the means for propelling vessels through fluids.

17324. August 18th. G. M. WINDSOR. Arrangement for the purpose of aerial flight.

17370. August 18th. R. D'EQUEVILLEY-MONTUSTIN. New or improved flight machine.

17413. August 19th. SIEMENS BROS. Improvements in and relating to airships.

17499. August 20th. C. DAVIES. Improvements in balloons, airships, and the like.

17502. August 20th. P. LENTZ. Improvements in or relating to aeronautical machines.

17695. August 22nd. O. RICOLDONI and G. A. CROCCO. Improvements in and relating to airships.

SEPTEMBER.

17798. August 25th. W. E. HITCH. Improvements in and relating to airships.

17855. August 25th. F. W. SCHROEDER. Improvements in aerial ships.

17877. August 25th. F. W. DAFWA. Improvements relating to flying machines.

17995. August 27th. F. W. BREWSTER. Improved aeroplane.

18059. August 27th. H. B. WEBB. Improvements in toy aeroplanes or flying machines, some principles of which are applicable to large machines.

18065. August 28th. F. W. LANCHESTER. Improved mechanism for imparting stability to an aerodrome in flight.

18084. August 28th. W. E. HITCH. Improvements in and relating to airships.

18197. August 31st. C. RUSSELL. Aero-propeller.

18223. August 31st. S. SCHUCKERTWERKE. Apparatus for determining the course of airships and the like.

18420. September 2nd. J. MACMILLAN. Improved air propeller or screw for use in air or water.

18696. September 7th. I. E. MERCIR. Improvements in the control of structures using aeroplanes.

18877. September 8th. M. KOBER. Improvements in or relating to rotating rudders for aerial machines.

18932. September 9th. F. WALTON. Improvements in or relating to flying machines.

19178. September 12th. J. WESTAWAY. Improvements in aeronautical machines.

19179. September 12th. J. WESTAWAY. Improvements connected with aeronautical machines.

19180. September 12th. J. WESTAWAY. Improvements connected with aeronautical machines.

19536. September 17th. C. G. RODECK. Improved balloon-aeroplane.

19677. September 18th. A. J. FREDRIKSEN. Improvements in flying machines or airships.

19805. September 21st. E. H. HARE. Improvements in aeroplanes.

19982. September 23rd. J. E. FRASER. Rotary orthopter aeroplane.

19985. September 23rd. G. DAWS. Improvements in dirigible balloons and airships.

20033. September 23rd. M. TWEEDIE. Improvements in aeroplanes.

20038. September 23rd. SIR H. S. MAXIM. Improvements in and relating to flying machines.

20110. September 24th. J. B. JUDGE and P. C. ROLLAND. Improvement in or connected with flying machines.

20160. September 25th. J. H. BROWN. Method of attaching caster wheels to aeroplanes or flying machines so called.